

Approach Spacing for Instrument Approaches (ASIA)

RTCA SC-186

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Overview / Abstract

Approach Spacing for Instrument Approaches

The approach spacing for instrument approaches (ASIA) application is an extension of the current instrument approach procedures. In this application, the flight crew uses the Cockpit Display of Traffic Information (CDTI) and an algorithm based approach spacing tool set in instrument conditions to achieve a desired spacing (no less than current Instrument Flight Rules (IFR) separation minima) at a point along the final approach. Closing to a minimum spacing allows for the closure of gaps between aircraft arrivals, and therefore increases runway throughput. The procedure could be extended, at a later point, to include an off final segment to allow for merging and more distance to reduce excess spacing.

Application Description

The description developed herein provides a preliminary definition of the application that includes the underlying pilot and controller tasks, roles, and- responsibilities in sufficient detail to allow for the specification of required capabilities to enable the performance of these tasks.

This application description is an initial stage in the process of fully developing an approach spacing application and will need to be followed by other development and implementation activities such as those outlined in RTCA, 1999. The procedures described in this document would undoubtedly undergo refinement prior to implementation. Full participation throughout the development process by all appropriate aviation organizations, including air traffic services; flight standards and aircraft certification offices; airlines, general aviation, military, and other users; avionics and airframe manufacturers; controller and pilot unions; and research and development organizations, is necessary for the accomplishment of the development and implementation process.

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Abbreviations

ASIA	Approach Spacing for Instrument Approaches
ADS-B	Automatic Dependent Surveillance-Broadcast
AOC	Airline Operations Center
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATIS	Automated Terminal Information System
CAASD	Center for Advanced Aviation System Development
CDTI	Cockpit Display of Traffic Information
CDU	Control and Display Unit
DAG	Distributed Air Ground
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FMS	Flight Management System
GPS	Global Positioning System
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
MASPS	Minimum Aviation System Performance Standards
MCP	Mode Control Panel
MITRE	MITRE
NASA	National Aeronautics and Space Administration
RA	Resolution Advisory
RTCA	RTCA
TCAS	Traffic alert and Collision Avoidance System
TESIS	Test and Evaluation Surveillance and Information System
TMC	Traffic Management Coordinator
TMU	Traffic Management Unit
TRACON	Terminal RADar CONtrol
VMC	Visual Meteorological Conditions
VOR	Very high frequency Omni-directional Radio

Definition of terms

CDTI- The pilot interface portion of a surveillance system. This interface includes the traffic display and all the controls that interact with such a display. The CDTI receives position information of traffic and own-ship from the airborne surveillance and separation assurance processing (ASSAP) function. The ASSAP receives such information from the surveillance sensors and own-ship position sensors.

Flight Crew- One or more cockpit crew members required for the operation of the aircraft.

Mixed Equipage- An environment where all aircraft do not have the same set of avionics. For example, some aircraft may transmit ADS-B and others may not, which could have implications for ATC and pilots. A mixed equipage environment will exist until all aircraft operating in a system have the same set of avionics.

Desirable- The capability denoted as Desirable is not required to perform the procedure but would increase the utility of the operation.

Required- The capability denoted as Required is necessary to perform the desired application.

Traffic- One or more aircraft or vehicle(s).

Target- Traffic of particular interest to the flight crew.

Selected Target- Target that has become distinguishable from other traffic as a result of being selected.

Target Selection- Manual process of flight crew selecting a target.

1 Approach Spacing

1.1 Introduction

1.1.1 Background

Managing the spacing between sequential aircraft on arrival paths in the terminal area can be challenging for both flight crew and ATC. Consequences exist for operating on either side of "optimum" spacing: If the trail aircraft is too close, a go-around may be necessary. On the other hand, if the trail aircraft is "too" far, runway capacity is reduced. Consistently achieving inter-arrival spacing that is closer to the optimum is an important step in increasing runway capacity for airports that are capacity-limited under instrument approach conditions.

There are many factors that determine the optimum spacing value, some of which are airport-specific. Runway exit geometry, for example, plays a major role in runway occupancy times, which is a key factor in runway capacity. In addition, practical limits are also placed on inter-arrival spacing due to wake turbulence concerns.

Regardless of what the optimum arrival spacing is, consistently working toward that optimum is problematic for both pilots and controllers. For the pilot on an instrument approach behind another aircraft, unless given a speed restriction, the pilot has no information to determine when to slow and configure the aircraft resulting in inconsistent spacing and, sometimes, controller intervention. Even with a speed restriction, e.g. "one eight zero to the marker", flight crews vary in when and how quickly they slow to final approach speed. In the case of ATC, there are several factors that also introduce imprecision. For example, dissimilar speed profiles and inconsistent configuration and speed changes, communication delays, radar data accuracy, the effects of wind gradients, and workload. Regardless of these factors, current ATC operations are very efficient in accommodating these factors and the realization of cockpit-based tools to improve this efficiency will not be trivial.

This approach spacing for instrument approaches (ASIA) application would allow the flight crew to adjust speed for their aircraft via a cockpit-based tool set to achieve to a desired minimum target spacing prior to the lead aircraft landing. After the lead aircraft has landed and prior to or at the FAF, the flight crew of the trail aircraft will decelerate to their target approach speed and become stabilized prior to landing.

This procedure builds from previous work done on approach spacing. NASA Langley has been developing an approach spacing concept for several years (Williams, 1983, Abbott, 1991, Abbott, 2002, and Oseguera-Lohr, 2002) and a paired approach concept was examined within RTCA (Bone, Mundra, and Olmos, 2001).

This application was originally identified in the Minimum Aviation System Performance Standards (MASPS) for ADS-B and is defined as application **D.1.11** (RTCA, 1998). The application is also defined at a high level in an appendix in the Safe Flight 21 Master Plan as Operational Enhancement #3: Improved Terminal Operations in Low Visibility operational application 3.2.2 Approach Spacing for Instrument Approaches (FAA, 2000). Additionally, this builds on several similar concepts including the Enhanced Visual Approaches as defined in RTCA (2000) and Operational Enhancement #3: Improved Terminal Operations in Low Visibility operational application 3.2.1 Approach Spacing for Visual Approaches as defined in the Safe Flight 21 Master Plan (FAA, 2000).

1.1.2 Operational purpose

The purpose of this application is to increase runway throughput by decreasing the variability of arrival spacing and to close up excess spacing between successive arrivals. Currently at busy facilities, ATC does very well at achieving high runway throughput so any tools placed on the flight deck will have to improve upon this efficiency.

1.1.3 Domain

The ASIA application is to be conducted in the terminal approach-controlled, surveillance airspace in a single stream approach operation under IFR. The weather minimums for the procedure are not expected to be different than those required of the instrument approach procedure to be followed (e.g., the ILS approach). The procedure could be conducted at airports that are either sparsely or densely populated with air traffic. It is expected that mainly commercial and business jets will be equipped to participate in the procedure. ASIA has the potential to be extended beyond just the final approach course in later implementations.

1.1.4 Justification

The main benefit from the ASIA is increased capacities at airports during IMC.

1.1.5 Maturity and user interest

The FAA Safe Flight 21 program office in coordination with a cargo airline association demonstrated an approach spacing concept in the Fall of 2000 during both VMC and IMC. The demonstration included both an advanced (computed speed command based on aircraft state data and approach geometry) and basic tool set (e.g., range ring, closure rate).

Two ASIA algorithms have been developed for RTCA SC-186 and Safe Flight 21. One was developed at NASA Langley and the other was developed at MITRE CAASD (see Abbott, 2002 & Wang and Hammer, 2001). As an incentive to accelerate the potential commercialization of this concept, the FAA provided seed money for avionics manufactures for the development and flight test of an approach spacing concept in a program called the Test and Evaluation Surveillance and Information System (TESIS). As part of the TESIS contract, a flight test is planned for 2003. Prior to this test, simulations

were conducted with flight crews and air traffic controllers at CAASD in a simulation facility (Bone, Helleberg, and Domino, in preparation). NASA Langley completed a high fidelity piloted simulation of their concept in January 2002 and plan to conduct a flight test in the fall of 2002. Additionally, the Langley ASIA interface is planned to be evaluated by flight crews at Atlantic City Airport (ACY). NASA Ames plans to evaluate an ASIA concept as part of their Distributed Air Ground (DAG) concept. A component of this evaluation is to further develop the flight crew interface. These tests and evaluations should provide additional information on the feasibility of the concept and the potential for implementation.

ASIA is in the early stages of development and coordination. Currently, user interest seems to be limited. The lack of interest may be due in part to the fact that the ASIA cost-benefit studies have yet to be conducted.

Depending on the implementation, the CDTI ASIA function may need to interface with systems such as the FMS, autothrottle, and the navigation display (if not implemented as a stand-alone CDTI). Equipment cost comparisons between CDTI-only and integrated implementations (e.g., implement the ASIA function in the FMS) are needed. Comparative flight crew workload studies need to be conducted in a realistic operational environment to determine the viability of CDTI-based ASIA concepts. Specific interface issues should include ASIA-specific information outside of the pilots' primary field of view, supporting alerting functions and the use of aural information relative to current industry alerting standards.

1.2 Operational concept, roles, and procedures

1.2.1 Concept description

System Level Perspective

The ASIA application is an instrument approach procedure involving at least two participating aircraft (i.e., a lead and a trail) and approved instrument approach procedures serving the runway to be used. ATC must pair compatible and eligible aircraft and place them on the final approach course with appropriate IFR separation (e.g., at least 3 nautical miles or 1000 feet). The trail aircraft within the designated pair then conducts the procedure by achieving a defined longitudinal spacing no less than current standard radar separation¹. The point at which this spacing is achieved is dependent upon the differences in final target speeds of the aircraft and the relative geometries of the participating aircraft. If the final target speed of the lead aircraft is faster than the trail, the minimum spacing may be achieved prior to the lead aircraft crosses the threshold. If the final target speed of the lead aircraft is slower, the minimum spacing may be achieved when the lead aircraft crosses the threshold. The flight crew will use a cockpit-based feature set to perform the spacing task.

¹ It is TBD whether this spacing is received from ATC or it is company procedure.

Both aircraft in the pair must be properly equipped. As a minimum, the lead aircraft must be equipped with Automatic Dependent Surveillance – Broadcast (ADS-B) and a Cockpit Display of Traffic Information (CDTI) (stand-alone or on a multi function display) supported by Global Positioning System (GPS). The trail aircraft must also be equipped with ADS-B, a CDTI, and ASIA tools if it is to fly in the tightly controlled ASIA “chain.” Initial analysis indicates that if the lead aircraft is not equipped and is not conducting the ASIA task that it will reduce the gains expected from the procedure, with a benefit reduction proportional to the ration of unequipped aircraft. This reduction may negate any benefit expected of the procedure unless, potentially, the “unequipped” aircraft is flying a standardized speed profile during the approach².

The ASIA application will require an ability of ATC to determine appropriate equipage of aircraft. This procedure need to function properly in a mixed equipage environment.

Traffic alert and Collision Avoidance System (TCAS) Resolution Advisories (RAs) will continue to function normally during ASIA operations.

Both aircraft will be required to have the specific avionics capabilities described in section 1.3.2.2 to participate in the procedure. The capability to participate in the procedure could be initially indicated in the flight plan³ or displayed as an icon on the controller traffic display.

Arrival and Initial Approach

Prior to entering the terminal area, flight crews will have obtained the destination airport Automated Terminal Information System (ATIS) or Digital ATIS and determined that ASIA in conjunction with the instrument approaches is being used.

Upon arrival in the terminal area, the aircraft are accepted by the feeder controller(s). The feeder controller(s) will know whether the aircraft and flight crew are capable of conducting the procedure by the information provided on the flight strip. This information will probably be displayed as an icon on the controller traffic display or provided in the remarks section of the flight strip,⁴ which would have been provided by the Airline Operation Center (AOC).

If aircraft are appropriately equipped, then on initial contact the feeder controller will instruct the flight crews to expect ASIA. The feeder controller(s) will then issue instructions as necessary and then hand-off the aircraft to the final controller(s). The flight crews are not required to perform any actions for the procedure at this point other than follow routine ATC instructions and brief the approach procedure for their expected runway.

² Such results are based on the fact that the aircraft is not conducting the approach spacing task and not from the quality of TIS-B data from the lead aircraft that could used by a trail aircraft to space on it.

³ It is possible that a suffix may be used in the next generation terminal automation system.

⁴ It is not expected that this information could be in the aircraft suffix, at least in the near term.

Establishment on the Final Approach

Once the aircraft are handed off from the feeder controller, the flight crews will then check in with the final controller(s) who will issue instructions to the flight crew to establish them on their final approach. The length of the final approach will need to be sufficient to ensure that adequate distance is available for the flight crew of the trail aircraft to make the final required speed adjustments to close to the desired spacing interval relative to the lead aircraft⁵.

As soon as possible, but no later than the intercept to the final approach course, the final controller will identify and communicate to the trail aircraft flight crew which aircraft they will be following.

The flight crew of the trail aircraft must acknowledge the final approach speed of the lead aircraft that is broadcast in the ADS-B message and automatically entered into the system as well as the desired interval. It is expected that the entry of landing speeds will be broadcast in the ADS-B message set; however, if it is not, it must be entered manually through the Control and Display Units (CDUs)⁶. Whenever desired, the flight crew of the trail aircraft can select the lead aircraft on their CDTI and arm the ASIA function, which will enable the ASIA tools to appear⁷. The final controller will continue to issue vectors and speed instructions such that the two aircraft are established on their final approach courses.

Approach Clearance

Once the aircraft are established on final and the final controller has decided to continue the procedure, the final controller will clear the lead aircraft flight crew for the instrument approach. The lead aircraft flight crew will intercept their localizer and fly the approach. This will include maintaining both lateral and vertical guidance, as appropriate.

The trail aircraft flight crew is expected to fly the speed assigned by the final controller until cleared for the approach and the ASIA tool set becomes engaged. The ASIA tool set will likely have certain requirements prior to engaging (e.g., the aircraft ground tracks within the pair must be within 20 degrees of each other). Once the ASIA function has engaged and the speed commands have appeared, the flight crew of the trail aircraft is expected to follow the speed commands provided by the algorithm. The trail aircraft flight crew now follows the ASIA speed commands to close to the desired longitudinal spacing from the lead aircraft. The ASIA tool set will include a spacing alert which will indicate to the flight crew that they are within the wake vortex boundary from the lead aircraft. It is

⁵ Realistic operational constraints will only allow for approximately a 1:20 closure to the desired spacing, i.e., a one mile error may be eliminated over a 20 mile flight segment.

⁶ It is to be determined, whether this exchange of expected landing speeds will take place manually or through a data link. An exchange through the ADS-B data link will require both aircraft to broadcast final approach speed information, and will require the aircraft to activate the procedure and identify the other aircraft on the display. Whether this entry will be into the FMS CDU or a separate CDU is yet to be determined.

⁷ At this time, it is expected that these tools will simply be CDTI tools; however, they may include certain flight control tools in order to reduce the workload.

not expected that this boundary will be exceeded except under unusual situations since this distance will be inside any chosen spacing criteria and ATC maintains wake and separation responsibility throughout the procedure. If the alert is triggered, the flight crew is required to determine the appropriate course of action based on the given conditions and pilot judgment.

At this point, the final controller has cleared both aircraft for their approaches and has advised them to contact the tower at the required position. Additionally, the flight crew of the trail aircraft is using the ASIA tools to fly the procedure. The proposed set of CDTI display symbols could include speed commands as well as other CDTI position indication cues. A spacing algorithm would provide speed recommendations for the trail aircraft that are used to achieve the minimum desired spacing prior to the lead aircraft landing.

Once the trail aircraft reaches the FAF, the active spacing task is discontinued and the trail aircraft flight crew will deceleration to and maintain its final approach speed (V_{ref} plus any necessary additions) to a normal landing. To reduce flight crew workload and to assure a stable final approach speed, the ASIA tool could provide a transition to the final approach speed, with appropriate display enunciation.

1.2.2 Procedures and responsibilities

1.2.2.1 Air traffic control

The **feeder** controllers are expected to:

- (1) Identify aircraft capable of conducting ASIA approaches;
- (2) Advise the appropriately equipped aircraft to expect ASIA (if necessary, request the planned target speed);
- (4) Vector aircraft for approaches;
- (5) Handoff aircraft to the final controller

The **final** controllers are expected to:

- (1) Identify aircraft pairs;
- (2) Advise the trail aircraft flight crew of the flight identification (if necessary, the planned final approach speed of the lead aircraft, and potentially the spacing interval);
- (3) Establish aircraft pairs on the approach with standard IFR separation at predetermined position on final approach course;
- (4) Clear lead aircraft for the approach;

- (5) Clear trail aircraft for the approach via ASIA; and
- (6) Advise the flight crews of both aircraft to contact the tower.

As with other approach operations, pilots will need to be informed that ASIA operations are being conducted. This is expected to occur through the ATIS.

1.2.2.2 Flight crew

Prior to ATC advising the flight crew of the aircraft to conduct ASIA on, the flight crew is expected to:

- (1) Obtain the destination airport's ATIS to determine if ASIA is in use;
- (2) Advise the feeder controller if unable to conduct the ASIA;
- (3) Enter for broadcast, the ownship final approach speed (V_{ref} plus any necessary additions);
- (4) If this information is not broadcast on the ADS-B message, inform the feeder controller of planned target speed;
- (5) Conduct appropriate approach briefs;
- (6) Contact the final controller;

When ATC has advised the flight crews of the aircraft to conduct ASIA on, the flight crew of the trail aircraft is expected to:

- (7) Identify the lead aircraft on the CDTI;
- (8) Distinguish / select the lead aircraft from other traffic on the CDTI (easier due to ATC use of aircraft identification);
- (9) Input the ASIA information for the ASIA algorithm as necessary (e.g., final approach speeds, desired spacing interval, minimum spacing interval)
- (10) Conduct the approach brief (if not already accomplished);
- (11) Intercept the approach
- (12) "ARM" ASIA (if tool set requires such a function);
- (13) When ASIA becomes enabled, follow the speed commands provided to achieve the spacing interval;

- (14) If the wake boundary spacing alert is triggered, the flight crew must determine the appropriate course of action based on the given conditions;
- (15) If appropriate, intercept the glide slope;
- (16) Deceleration to the planned approach speed inside the FAF; and
- (17) Fly the planned final approach speed inside the FAF.

The flight crew of the trail aircraft should notify ATC immediately of any degradation of aircraft or navigation systems that may lead to their inability to perform the procedure. Flight crews should also notify ATC if at any point they are unable to continue the approach and need breakout instructions. The flight crew of either aircraft should immediately inform ATC if a change in planned final approach speed is necessary.

1.2.2.3 Airline Operations

The AOC could be responsible for assuring that the flight plans indicate whether or not the aircraft and flight crew are qualified to conduct the procedure. It is expected that this will be done in the remarks section of the flight plan. A future capability may allow this to be noted in the aircraft suffix or to be displayed as an icon on the controller traffic display.

1.2.2.4 Flight Service Stations

Flight service stations are not expected to be directly involved in this application.

1.2.3 Proposed new phraseology

Communications will involve the use of flight identification and may include the transmission of the appropriate spacing interval for the trail aircraft. It is yet to be determined if flight identification can be used with existing phraseology. This question is also being addressed during the development of the concept.

1.2.4 Aircraft separation / spacing criteria

It is not expected that this application will reduce current separation minima. The spacing to maintain behind the lead aircraft will be outside any radar or wake vortex separations. How this spacing is determined is to be defined. The ASIA tool set will include a spacing alert which will indicate to the flight crew that they are within the wake vortex boundary from the lead aircraft. It is not expected that this boundary will be exceeded except under unusual situations since this distance will be inside any chosen spacing criteria and ATC maintains wake and separation responsibility throughout the procedure. If the alert is triggered, the flight crew is required to determine the appropriate course of action based on the given conditions and pilot judgment.

1.2.5 Sample scenarios

The following example describes the procedure as it may be applied at Airtown (KAIR) airport on runway 16. In this sample scenario, TRL 44 and LED 525 are the aircraft arriving for the approach. Both aircraft are Boeing 737s and have ADS-B, CDTIs, and are ASIA capable. TRL 44 is arriving from the southwest and LED 525 is arriving from the southeast. The surface winds are from 190 degrees at 10 knots (see **Figure 1**).

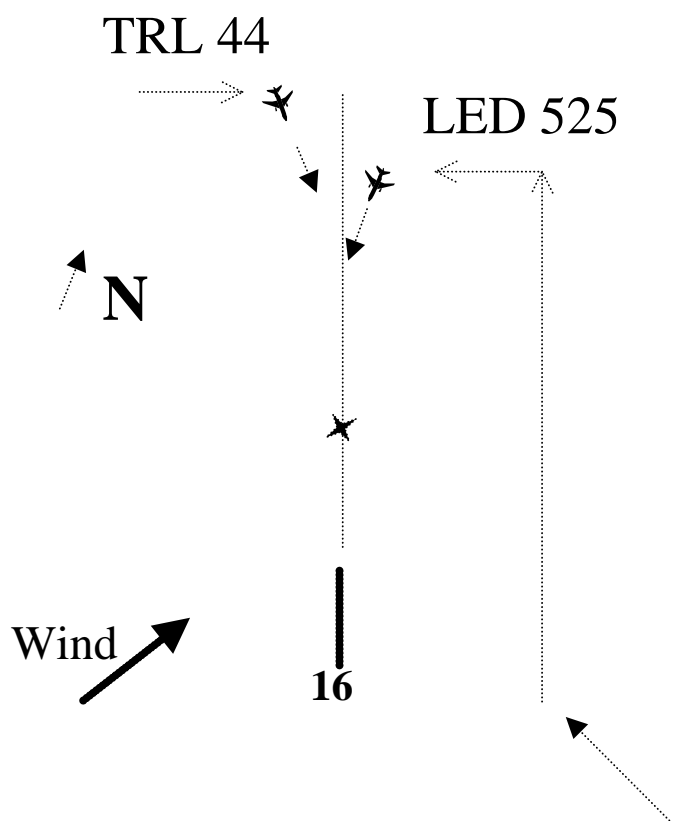


Figure 1. KAIR ASIA Plan View

Prior to arriving in the KAIR area, both aircraft flight crews are notified by the KAIR ATIS Delta that ASIA operations are being conducted. Since both aircraft are properly equipped and both flight crews are properly trained in the procedure, they are able to conduct the procedure. These flight crews then brief the approach to include the ASIA procedure. At this time, the flight crews also enter the preliminary ASIA data into the CDTI (e.g., surface winds).

As the aircraft approach the KAIR area, the approach control traffic management unit (TMU) determines that TRL 44 and LED 525 and other aircraft can conduct the ASIA task based on equipage and their expected approach sequencing. The TMU then adjusts the arrival rate accordingly.

As TRL 44 and LED 525 approach the terminal area, the ARTCC executes the hand-offs and instructs the flight crews to contact approach control. The aircraft then check in on the assigned frequency with Approach Control. The West and East Feeder Controllers will tell TRL 44 and LED 525, respectively, to expect the ASIA approach, along with any necessary instructions.

TRL 44: “Airtown Approach, TRL four four level at one zero thousand with information Delta.”

West Feeder Controller: “TRL four four, Airtown Approach. Radar contact. Expect ASIA Runway 16. Traffic to follow will be LED 525, target distance three and one half miles⁸.”

TRL 44: “TRL four four expect ASIA Runway 16. Traffic to follow will be LED 525, target distance three and one half miles”

LED 525: “Airtown Approach, LED five twenty five at one zero thousand with Delta.”

East Feeder Controller: “LED five twenty five, Airtown Approach. Radar contact. Expect ASIA Runway 16.”

LED 525: “LED five twenty five expect ASIA Runway 16.”

The feeder controllers issue vectors and speed instructions, as necessary, to the aircraft, hand off to the approach control final controller, and instruct the flight crew to contact the final controller. As soon as the flight crews have determined their final approach speed, Vapp (Vref plus any necessary corrections) and have the available time, they will enter that number in the CDU for broadcast via ADS-B (this is in the message set being transmitted to other aircraft). In this case, the final approach speeds for LED 525 and TRL 44 are 135 and 145 knots, respectively. The final controllers continue to issue altitude and heading instructions to both aircraft as necessary to establish them on the final approach course, level, with standard IFR separation.

As the flight crews are receiving vectors, the flight crew of TRL 44 selects LED 525 on the CDTI. Once the aircraft is selected, additional information is provided to the flight crew in a datablock. This information includes LED 525’s ground speed, range, flight identification, and weight category (see **Figure 2**). The fact that LED 525 is selected on the CDTI is passed through the FMC so that other on-board systems may access that information.

⁸ The means by which this information is conveyed to the flight crew is TBD.

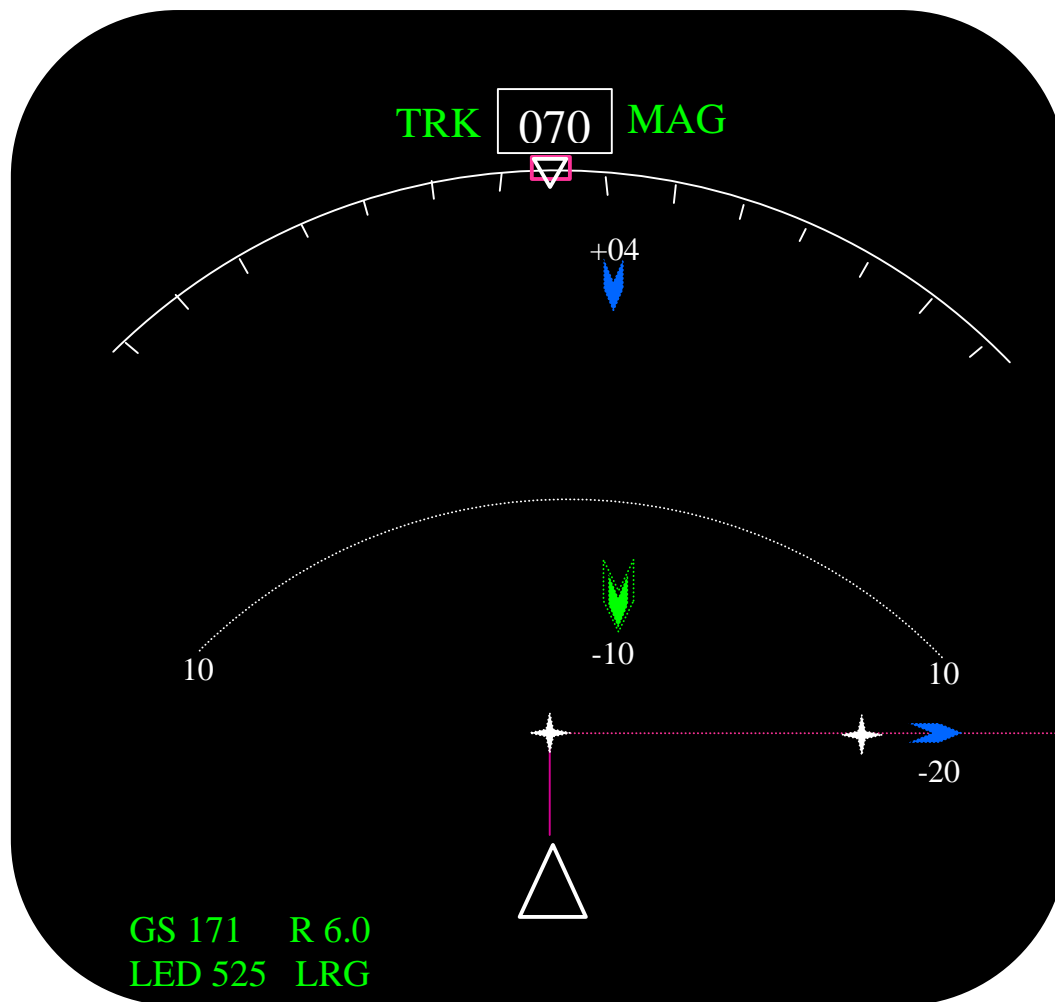


Figure 2. Cockpit Display of Traffic Information (CDTI) with aircraft selected.

At this point the flight crew of TRL 44 would interact with the CDU by entering or confirming the necessary information for the ASIA procedure (see **Figure 3**). This interaction includes confirming the expected lead aircraft identification and that it has reported a final approach speed. For TRL 44, this confirmation includes the lead aircraft identification of LED 525 and 135 knots. They will also confirm their own final approach speed. Since the ownship final approach speed was previously entered and the FMS had knowledge of the selected aircraft and its broadcast final approach speed, this information is automatically entered into the associated fields. The flight crew must enter the target spacing interval though⁹. The flight crew will then arm the ASIA function.

⁹ How this target spacing interval is determined and conveyed to the flight crew is TBD.

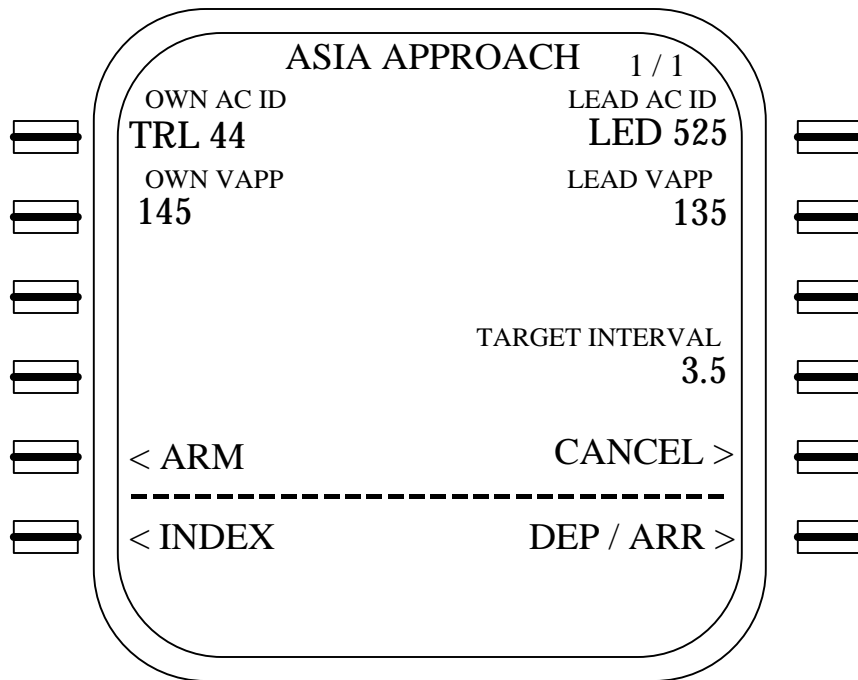


Figure 3. Completed Sample ASIA Control and Display Unit (CDU) Page.

The following communications then occurs prior to intercepting final.

Runway 16 Final Controller: “LED five twenty five, eight miles from FFAFF. Turn left heading one nine zero. Maintain four thousand until established on the localizer. Cleared ILS runway one six. Maintain one seven zero knots till FFAFF. Contact tower at FFAFF.”

Flight crew LED 525: “LED five twenty five, left to one nine zero. Maintain four thousand till established. Maintain one seventy knots till FFAFF. Cleared ILS one six. Contact tower at FFAFF.”

After LED 525 has been cleared for ILS to runway 16, the flight crew follows the localizer and glide slope (upon interception), and flies their instructed speed and then their final approach speed after the FAF to a normal landing.

Runway 16 Final Controller: “TRL four four, thirteen miles from FFAFF, turn right heading one three zero. Maintain five thousand till established. Cleared ASIA runway one six behind LED 525.”

Flight crew TRL 44: “TRL four four, turn right heading one three zero. Maintain five thousand till established. Cleared ASIA one six behind LED 525.”

Since the flight crew of TRL 44 has already selected and confirmed the information for LED 525 no further flight crew actions are necessary. If another aircraft was instead the

lead, they would need to select that aircraft and make the appropriate entries and confirmations of information.

After TRL 44 intercepts the localizer, the ASIA function is able to become engaged. When the ASIA function transitions from armed to engaged on TRL 44, and the speed cues appear, the flight crew will begin the spacing task by following the ASIA speed commands. For example, when the hollow cyan commanded speed bug appears on the PFD airspeed tape it indicates that the required speed is 200 knots (see **Figure 4**) since there is still some distance to close prior to achieving the target distance. The flight crew then matches the magenta autothrottle speed bug with the commanded speed bug to achieve the commanded speed. The flight crew continues these speed reductions, as necessary, along final approach. If at any point the wake boundary spacing alert is triggered, the flight crew must determine the appropriate course of action based on the given conditions. It is not expected that this boundary will be exceeded except under unusual situations since this distance will be inside any chosen spacing criteria and ATC maintains wake and separation responsibility throughout the procedure.

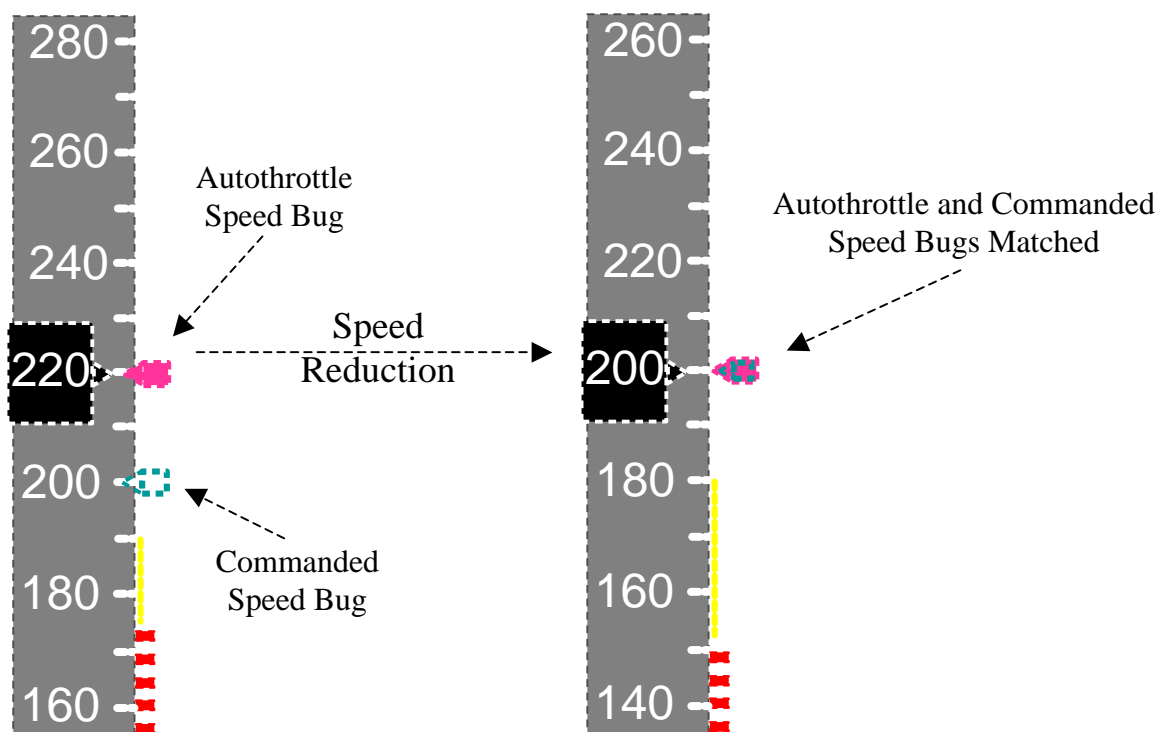


Figure 4. Sample ASIA Speed Cues on Airspeed Tape.

The flight crew continues to track the localizer, intercepts the glide slope, and flies the ASIA speed commands to the Final Approach Fix (FAF). At the FAF, the commanded speed bug is placed at the final approach speed entered by the flight crew in the CDU and

the flight crew no longer actively maintains ASIA spacing¹⁰. They slow to their final approach speed and continue to a normal landing.

1.3 Requirements

1.3.1 Display & Interface / Functional

[Table needs to be finalized once master table in MASPS is complete]

The ASIA CDTI features are list in **Error! Reference source not found.** (for all potential features see **Table ???**). The features labeled as “**Required**” in the need column are believed to be necessary to perform the ASIA application. Those labeled as “Desirable” are not required to perform the procedure but would increase the utility of the operation.

Display Elements	Display Range Reference	R
	Track Up / Heading Up / Course Up Map Mode	R
	Target Selection	R
	Algorithm commanded speed indication	R ¹
Symbols	Own-Ship	R
	Traffic	R
	Selected Target	R
Traffic Elements	2D Positioning Information	R
	Altitude (Relative or Absolute)	R
	Identification ²	R
Selected Traffic Elements	Highlighting	R
	Identification	R
	Category	R
	Ground Speed	D
	Range	D
	Closure Rate	D
	Off-Display Selected Target Relative Bearing	D
Alerting Elements	Visual Alert	R?
	Aural Alert	R?

Notes:

R = Required

D= Desirable

¹⁰ Optionally, the ASIA speed command can provide a scheduled deceleration to the final approach speed, thus reducing crew workload.

1. This information could be placed elsewhere in the cockpit such as on the Primary Flight Display.
2. If required, should be available for display but not necessarily continually displayed.

Table 1. ASIA display requirements.

The flight crew will need the following capabilities.

- (1) View the flight identification, horizontal position, and altitude of surrounding traffic;
- (2) Select and highlight a specific target on the display;
- (3) Select the ASIA function;
- (4) Input and / or confirm the final approach speed for own aircraft and input and / or confirm the other aircraft flight identification and final approach speed and the desired spacing interval;
- (5) Arm the ASIA tool (if the tool set requires such a function);
- (6) Determine that the approach algorithm is operating normally;
- (7) Display lead aircraft information to assist in monitoring the longitudinal distance with the lead aircraft (e.g., ground speed, range read-out);
- (8) Determine / view the lead aircraft position for a safe interval;
- (9) View and utilize the ASIA tool (e.g., speed guidance) to assist in acquiring the desired spacing interval;
- (10) Determine when own ship has achieved the desired spacing interval, when own ship is approaching the minimum spacing interval (which may be different than the desired spacing interval), and at a breakout point; and
- (11) Determine when the spacing task is to be discontinued.

Different forms of alerting may also be a requirement for the CDTI. Required alerts include a spacing alert which will indicate to the flight crew that they are within the wake vortex boundary from the lead aircraft as well as a surveillance alert indicating degraded surveillance information. Another alert could be an alert indicating that the minimum spacing will be broken at some point in the near future. An alert may also be required that indicates a maximum spacing which the flight crew should not exceed. These alerts may need to be both visual and aural. The alerting requirements shall conform to current industry standards and practices.

The controller will need the capability to:

- (1) Identify appropriately equipped aircraft (e.g., traffic display icon, flight strips, datablock).

The controller may need the capability to:

- (1) Identify aircraft that are not conforming to the ASIA clearance (via an ADS-B conformance message from the non-conforming aircraft).

1.3.2 Infrastructure Requirements

1.3.2.1 Ground ATC

A capability for designating appropriate equipment by aircraft to ATC will be required.

TIS-B infrastructure is unnecessary for the procedure since its use is not expected to be beneficial.

1.3.2.2 Flight Deck

The ASIA application requires that aircraft to be paired are equipped with an appropriate level of ADS-B and CDTI. These include the capabilities to:

- (1) Transmit appropriate position;
- (2) Transmit final approach speed data¹¹;
- (3) Transmit weight class or aircraft category data
- (4) Access the appropriate ASIA tools;
- (5) Input certain parameters; and
- (6) Select and activate the ASIA procedure.

Depending on the tool set used and the workload required, coupling the speed commands to the autothrottle may be required. Such a system has been analyzed previously and flight crews believed it to be a possible implementation (Bone, et al. 2000). However, even though it reduces pilot workload, it could be an expensive implementation.

It may be that an FMS will act as an interface to the CDTI so that the flight crew is able to enter the necessary parameters (e.g., final approach speeds). Assuming that the aircraft has an existing autothrottle and given this FMS assumption, the specific issue of autothrottle expense, noted above, may be eliminated if the ASIA algorithm is implemented in the FMS. In this implementation, the ASIA speed mode would become just another FMS speed mode.

1.3.2.3 Airlines Operations Center & Flight Service Stations (if applicable)

There are no infrastructure requirements for the AOC.

1.4 Other Considerations

1.4.1 Relationship to other programs and future enhancements

The FAA Safe Flight 21 program office in coordination with a cargo airline association demonstrated an approach spacing concept in the Fall of 2000 (see FAA, 2001, & Olmos, Bone, Domino, 2001).

¹¹ It may be possible to accomplish this procedurally.

Work previously conducted on a Paired Approach spacing task to closely spaced parallel runways aided in the development procedures and the spacing tool set of this application (see Bone, Mundra, Olmos, 2001).

1.4.2 Training requirements

A candidate flight crew training syllabus is provided in Oseguera-Lohr, 2002, with the training mimicking traditional airline training for a new procedure. The training footprint was approximately two hours which included approximately one hour of simulator training. The training was reported to be adequate by the test subjects.

1.4.3 Other issues

1.4.3.1 Issue: What is the appropriate tool set for approach spacing in instrument conditions?

Is an algorithm that provides speed commands necessary? Are tools such as a range ring and closure rate sufficient?

Priority: High

Resolution Method: Flight simulation, flight test, analysis

Status: Open

Resolution: [*Detailed discussion*]

1.4.3.2 Issue: Is a CDTI outside the primary field of view or information on the navigation display adequate for approach spacing in instrument conditions?

Does the ASIA information needed to be integrated into the pilots' primary flight display? Is a spacing tool, outside of the pilots' primary field of view, adequate for this application? This issue is likely related to the ASIA tool set.

Priority: High

Resolution Method: Flight simulation, flight test, analysis

Status: Open

Resolution: [*Detailed discussion*]

1.4.3.3 Issue: What is the minimum spacing for the flight crew to achieve?

The minimum spacing to be achieved by the flight crew is directly related to the issue of who is responsible for separation and is likely related to the ASIA tool set.

Priority: High

Resolution Method: [e.g., discussion, literature search, flight simulation, flight test, analysis, modeling]

Status: [e.g., open, closed]

Resolution: [Detailed discussion]

1.4.3.4 Issue: Issuance of spacing instruction

Who will determine the required spacing for the flight crew to maintain? Will ATC provide the spacing instruction to the flight crew? What are the issues if ATC is to provide the spacing? What are the issues if the company or the pilot determines the desired spacing?

Priority: High

Resolution Method: [e.g., discussion, literature search, flight simulation, flight test, analysis, modeling]

Status: [e.g., open, closed]

Resolution: [Detailed discussion]

1.4.3.5 Issue: FMS equipage

Do all aircraft need to be FMS equipped? Does equipage depend on conditions, i.e., IMC vs. VMC? The algorithm may need aircraft performance speed ranges for commanded speed limits. If an FMS is not used, how will the flight crew interface with the CDTI?

Priority:

Resolution Method: [e.g., discussion, literature search, flight simulation, flight test, analysis, modeling]

Status: [e.g., open, closed]

Resolution: [Detailed discussion]

1.4.3.6 Issue: What kind of speed commands would be acceptable operationally

Are only speed decreases acceptable? Are both speed increases and speed decreases operationally acceptable? What are the minimum and maximum speed changes operationally acceptable (e.g., 1 knot increments, 5 knot increments)?

Priority:

Resolution Method: [e.g., discussion, literature search, flight simulation, flight test, analysis, modeling]

Status: [e.g., open, closed]

Resolution: [Detailed discussion]

1.4.3.7 Issue: What if the desired spacing goal can not be achieved ?

If the desired minimum spacing goal cannot be achieved, what should be the proper behavior of the approach spacing tool set? Should it continue to give speed commands to allow for some closure?

Priority:

Resolution Method: [e.g., discussion, literature search, flight simulation, flight test, analysis, modeling]

Status: [e.g., open, closed]

Resolution: [Detailed discussion]

1.4.3.8 Issue: Is the final approach speed transmitted in the ADS-B message set?

If not, ATC transmit?

Priority:

Resolution Method: [e.g., discussion, literature search, flight simulation, flight test, analysis, modeling]

Status: [e.g., open, closed]

Resolution: [Detailed discussion]

1.4.3.9 Issue: Should a non-conformance variable be transmitted in the ADS-B message set?

Would a non-conformance message with appropriate ATC display enhance ATC acceptability and usability of this concept?

Priority:

Resolution Method: [e.g., discussion, literature search, flight simulation, flight test, analysis, modeling]

Status: [e.g., open, closed]

Resolution: [Detailed discussion]

1.4.3.10 Issue: Environment input requirements

What environmental inputs are necessary for tool accuracy, e.g., winds, temperature? Are required inputs different for VMC and IMC procedure?

Winds- How are the winds measured and set to aircraft? Are surface winds sufficient? What are the effects on alerting and false alarm rates?

Priority:

Resolution Method: [e.g., discussion, literature search, flight simulation, flight test, analysis, modeling]

Status: [e.g, open, closed]

Resolution: [Detailed discussion]

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